NASA, Goddard Space Flight Center, Greenbelt, Md.

AN OMNI-DIRECTIONAL ANISOTROPIC CHAMBER

3p

H. Shapiro and W. F. Hardgrove [1964] 3p

[redacted]

(NASA TMX-51272)

INTRODUCTION

With the advent of more sophisticated spacecraft, the need arises for more detailed testing of these craft before they become operational. Among the many problems facing the test engineer is the problem of molecular "bounce-back" within the vacuum chamber. Molecules emitted from the "skin", structure, power pack, electronics and plastic encapsulation materials leave the craft, rebound from the vessel walls, and a statistical number impinge upon the test craft or component.

Submitted for Publication

In order to estimate the probable functioning life in space of these craft, vapor pressure studies are undertaken based upon Langmuir's method. Where the material is organic in composition, i. e., plastics, elastomers, etc., the method most frequently used is empirical and consists of recording the time taken for a sample to lose some given fraction of its weight. This decrease in weight of a component as a time-temperature function could be erroneously interpreted where returning molecules constitute a measurable fraction of the total weight change. So, studies in a chamber environment may ascribe unreal lifetimes to a functioning spacecraft where its actual environment precludes the return of any molecule to the craft's surface. Space acts as an infinite sink for molecules leaving the surface, thus shortening computational lifetimes.

In our laboratory we have constructed a space surrounded in the X, Y and Z planes by deflecting surfaces. A vaporizing component in this space emits molecules which may leave unhindered, but which face a deflecting plane upon re-entry. A cubical space is thus provided within which vaporization phenomena may be studied with greater assurance that the results will be more typical of those found in interplanetary regions or beyond.

PRINCIPLES

If the smaller ends of six truncated pyramids are joined together, they enclose a cubic space which is the test area. (Figure 1) Using the simplyfing assumption that at background pressures below 10^{-7} torr, molecular flow has many properties of light beams, a molecule rebounding from a reflective plane surface will do so at an angle equal to its angle of incidence. Our pyramids were constructed from polished sheet copper and gold plated, with axial angles of 15°. A molecule entering such a configuration (Figure 2) will rebound according to the equation

$$\theta_2 = \theta_1 + 2S$$

θ_2 = rebound angle

θ_1 = entering angle

S = axial slope of the plane wall.

It can be seen that a molecule will rebound from any face with an incremental angle equal to 2S, thus many molecules are returned to the space from which they entered, outside the confines of the configuration.

EXPERIMENTAL

The ODAC was suspended in the center of a stainless steel vacuum chamber. An evaporating source consisting of a tungsten filament was hung in the central test space. A "satellite" was fabricated from sheet copper and consisted of two pieces about one inch square welded together, one in the horizontal plane, one in the vertical plane. This was suspended over the evaporating source so that the horizontal piece was directly above the filament and effectively shielded the vertical piece from direct evaporation. (Figure 3) The vessel was evacuated until the background pressure reached 10^{-7} torr. Several different materials were evaporated in an attempt to coat the vertical fin by reflection from the walls of the chamber. Two metals, silver and aluminum, were tried. These appear to have a high accommodation coefficient and even when the walls of the chamber were at 350°F, insufficient molecular return was observed to form a coating on the

[redacted]

vertical fin. The measure of "bounce-back" molecular action taken was the amount of material deposited on the outside sloping planes. These surfaces could be coated only if the "bounce-back" phenomenon were present. The filament was replaced by a tungsten boat and anthracene was evaporated, using ultra-violet illumination to observe the course of evaporation. When several grams of anthracene had undergone evaporation, the entire chamber and its contents fluoresced, with the sole exception of the "satellite" vertical fin. The walls, ports, pump throat and, more germane, the outside surfaces of the ODAC were brightly illuminated, indicating that the sought-for phenomenon had, in fact, taken place. This experiment was repeated without the ODAC. Again, at the end of the evaporation, the entire chamber and its contents exhibited fluorescence including the vertical fin. (Figure 4)

CONCLUSIONS

There have been many experiments performed that illustrate the inadvisability of considering molecular reflection from polished plane surfaces as specular. However, using the simpler approach that molecules are specularly reflected, then a baffle may be constructed so that molecules may be prevented from returning to an emitting source.